DOCUMENT RESUME


ED 433 986 RC 022 088

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|---|---|
| AUTHOR | Bickel, Robert |
| TITLE | School Size, Socioeconomic Status, and Achievement: A Texas Replication of Inequity in Education with a Single-Unit School Addendum. |
| PUB DATE | 1999-08-00 |
| NOTE | 67p.; For other school size reports, see ED 433173-5 and RC 022 087. |
| PUB TYPE | Numerical/Quantitative Data (110) -- Reports - Research (143) |
| EDRS PRICE | MF01/PC03 Plus Postage. |
| DESCRIPTORS | *Academic Achievement; *Economically Disadvantaged; Elementary Secondary Education; Enrollment; Regression (Statistics); School District Size; *School Size; Small Schools; Socioeconomic Influences; *Socioeconomic Status; Tables (Data) |
| IDENTIFIERS | Interaction (Statistical); *Texas; *Unit Schools |



ABSTRACT

Recent research in West Virginia and California has linked school size to both effectiveness and equity, finding that as school size increased, the mean achievement costs for schools with less-advantaged students became more burdensome. An effort was undertaken to replicate this research in four states offering a variety of school settings and conditions. This report describes analysis of 1996-97 data from 6,288 Texas schools using a multiple regression equation in which the dependent variable was mean achievement test score and independent variables were school size (enrollment per grade level being analyzed), percent of enrollment eligible for free or reduced-cost lunch, and a multiplicative interaction term. Various test scores were analyzed for grades 3, 5, 8, and 10. In 9 of 10 analyses, statistically significant and negative interaction effects were found, such that achievement in schools with less advantaged students decreased as school size increased. Effects were very strong for grades 8 and 10. Similar analysis for district size found no effects for grades 3 and 5, but a significant negative main effect was found for grades 8 and 10, such that achievement levels for all students decreased as district size increased. Separate analysis of size effects in 132 single-unit (K-12) schools, which averaged much smaller enrollments per grade level than other schools, found very few interaction effects and a weakened direct effect of socioeconomic status. (Contains 47 references and 27 statistical data tables.) (SV)

# SCHOOL SIZE, SOCIOECONOMIC STATUS, AND ACHIEVEMENT: A TEXAS REPLICATION OF INEQUITY IN EDUCATION with A Single-Unit School Addendum

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## ABSTRACT

Research on the consequences of variability in school size has a long history. As with so many variables in educational research, empirical investigations of school size effects, over the years, have yielded conflicting results. This has led some researchers to treat school size as a control variable which they are obliged to employ, but which is otherwise uninteresting. Recent research, however, has linked school size to both effectiveness and equity in a new and interesting way: as school size increases, some have found, the mean achievement costs for schools with less-advantaged students become more burdensome. The first reports of this finding and its educational policy implications were based on research using data from California and West Virginia. In an effort to determine if results from these two very different states can be generalized to other settings, we replicated the research using first Georgia data and now Texas data. As with Geogria, our findings for Texas are the same as those reported for California and West Virginia: as Texas schools become larger, achievement costs associated with less-advantaged students increase. Finding the same school size effects in four such distinctive states lends substantial credibility to claims that the results are widely generalizable.

"Educational researchers and policymakers have never met an issue they were willing to resolve once and for all. School size is a case in point." With those observations, we opened a recent research report based on a Georgia data set containing information for 1996-97 on 1626 schools and 174 school districts.

The Georgia research was prompted by size-by-socioeconomic status interaction effects first reported for California and West Virginia (Friedkin and Necochea, 1988; Howley, 1996). Our objective in the Georgia research was replication of this earlier work to see if the same interaction effects held at the school-level and district-level in Georgia. We were again asking if school-level achievement losses associated with less-advantaged students are exacerbated as school size increases?

In this report we extend our work to include the state of Texas. Our 1996-97 Texas data set includes 6288 schools and 960 school districts. Using this data we ask the same timely questions addressed in our Georgia research: do we again find size-by-socioeconomic status interaction effects? Do we again find that school-level achievement losses associated with less-advantaged students are exacerbated as school size increases?

CREDIBILITY THROUGH REPLICATION

At the school level, the Georgia effects were striking: as school size increased mean achievement costs for schools with less-advantaged students increased. Results were remarkably consistent from grade to grade, 3, 5, 8, and 11, and across all eight sections of the Iowa Test of Basic Skills and all five sections of the Georgia High School Graduation Test.

The same kinds of school-level effects have now been found in enormous, trend-setting, internally heterogeneous California; in small, rural, internally homogeneous, mid-Atlantic West Virginia; and in medium-sized, demographically unexceptional, deep-southern Georgia, a state with an abundance of urban, suburban, and rural schools. This emerging pattern of replication in varied and distinctive states lends credence to the claim that size-by-socioeconomic status interaction effects are of general importance.

One Size Does NOT Fit All

Research results such as this give the lie to a one-size-fits-all point of view. Within any school, it may have once seemed, size-related benefits accrue and size-related costs are borne equally by all students (Conant, 1959; Haller, 1992; Haller, Monk, and Tien, 1993; Hemmings, 1996). Our Georgia analyses, however, coupled with the earlier research which they replicate, provide credible evidence that this is not the case.

Bringing Equity Back In

Renewal and refocusing of the school size debate in line with the foregoing casts doubt on the wisdom of the scientific management mind-set which is the source of the dominant perspective in education policymaking today. Rather than giving near-exclusive emphasis to organizational effectiveness and economies of scale (Tholkes and Sederberg, 1990; Haller, Monk, Bear, Griffith, and Moss, 1990; Purdy, 1997; Stevenson, 1996), equity issues are reintroduced and given a conspicuous place in discussions of school size (see, for example, Walberg and Walberg, 1994; Stevens and Peltier, 1995; Fowler, 1995; Mik and Flynn, 1996).

One-size-fits-all assertions are now less often taken for granted. Some researchers and policymakers, as a result, are asking best-size-for-whom (Huang and Howley, 1993; Henderson and Raywid, 1994; Devine, 1996)?

## REPRODUCIBLE FINDINGS: A RESEARCH AGENDA

Even with the additonal substantiation provided by the Georgia report, however, research on size-by-SES interactions still lacks persuasively broad geographic scope. Once again, therefore, as has been the case for so many promising educational research outcomes, there exists the possibility that investigations done in other locations will yield different, perhaps sharply conflicting results.

Consequently, we have sought to replicate this recent research on size-by-SES interaction effects once again, in another distinctive setting. This time our data covers the state of Texas.

### Replication in Texas

Texas is enormous in population, physical area, and national economic and political clout. It is rooted historically in the culturally powerful traditions of the old confederacy, the mythically wild west, and mid-19th century Manifest Destiny.

Texas is, moreover, a state of demographic, social, and educational extremes: urban density and rural isolation; all-white suburbs, Hispanic barrios, and big city ghettos; third world limits of wealth and poverty.

The state's system of public education includes more than 6000 schools, ranging in enrollment from as few as 1 to just over 4500. There are nearly 1000 school districts, with total enrollments as small as 16 and as large as 160,000 (Texas Education Agency, 1999).

Texas, undeniably, is a one-of-a-kind state. The credibility of claims to generalizability for size-by-SES interactions will be further enhanced if such effects are also found in Texas schools.

On the other hand, if Texas results contradict findings from other states, or if the interaction effects are simply missing, arguments for generalizability lose credence. We may, once again, be left with interesting findings which prove to be unpredictably situation specific, or simply ambiguous (Hallinan, 1989; Burtless, 1996).

## TEXAS DATA: OPERATIONALIZING CONCEPTS

The Texas data set, fortunately, includes the kinds of measures needed for an effective replication. Outcome variables are well-suited to the task at hand, as are explanatory factors.

### Dependent Variables: Texas Assessment of Academic Success

The dependent variables or outcome measures we will use for the 8th and 10th grades are mean school-level raw scores for three subtests of the Texas Assessment of Academic Success (TAAS) battery. The subtests are designed to measure achievement in reading, mathematics, and writing.

Only two of the three subtests, reading and mathematics, are reported by the Texas Education Agency for the 3rd and 5th grades. These will be the outcome measures for the elementary level.

The TAAS has been employed as a statewide student assessment tool and gauge of school effectiveness since the fall of 1990. It is intended to be a comprehensive measure of broad instructional objectives mandated by the state. The TAAS is designed to target higher-order thinking skills and problem-solving ability, a departure from an earlier emphasis on basic skills.

Dependent Variables that Vary

Mean achievement levels on all sections of the TAAS vary dramatically from school to school. For example, school mean scores on the reading section range from 1 to 48 for the 3077 schools reporting for grade 3; from 10 to 45 for the 2855 schools reporting for grade 5; from 3 to 49 for the 1449 schools reporting for grade 8; and from 25 to 48 for the 1199 schools reporting for grade 10. Variability in mathematics and writing is just as striking.

Independent Variables

Indepedent variables used in the analysis are the same ones used in the research we are replicating: percent of all students eligible for free and reduced cost lunch (FREEPCT), and the number of students per grade level in thousand-student units (SPANSIZE). In addition, the interaction term (INTERACT), created by multiplying FREEPCT by SPANSIZE, serves as a third and crucial independent variable in each equation.

Grade spans range from one to thirteen, the latter representing 132 single-unit schools with grades K through 12. Total enrollment, as already noted, ranges from 1 to just over 4500 students. Enrollment by grade level, our SPANSIZE independent variable, ranges from less than 1 to 1480. The SPANSIZE mean for all schools is 155.

The percentage of students eligible for free or reduced cost lunch (FREEPCT), ranges from 0 to 100. The mean percentage for all schools is 49.8.

## ANALYTICAL PROCEDURES

Identification and measurement of relationships in the Texas data will be accomplished, as in the Georigia analyses and the research they replicated, through straightforward application of multiple regression analysis.

### Identifying Comparable Results

Comparability with prior research, if found, will be manifest in statistically significant and negative interaction terms created by multiplying together the school size and SES variables. If comparability is present, we will take this to mean that in Texas, too, as school size increases, the mean performance loss associated with less-advantaged students is exacerbated.

## Calculating Effect Size

After the Texas regression analyses have been done, we will use the procedure employed by Friedkin and Necochea (1988) to calculate gains and losses which may be associated with increasing school size. Specifically, partial derivatives will be taken for each regression equation, gauging the impact of school size while holding constant percent eligible for free or reduced cost lunch.

## A Regression Equation

By way of illustration, in our earlier Georgia analysis we obtained mean eighth grade reading comprehension scores on the Iowa Test of Basic Schools for 371 Georgia secondary schools. We used these mean scores as values for the dependent variable in a multiple regression equation in which school size (measured in thousands of students per grade level) and percent eligible for free or reduced cost lunch were used as independent variables. The equation also included the multiplicative interaction term created from the two independent variables. In other words, the independent variables were those we have termed FREEPCT and SPANSIZE, along with the interaction term, INTERACT.

Regression analysis of the illustrative Georgia data yielded the following equation, where Y is mean reading comprehension score, X is SPANSIZE, Z is FREEPCT, and XZ is INTERACT:

$$Y = 61.689 + 20.969X - 0.309Z - 0.560XZ$$

Since all partial regression coefficients were statistically significant, the equation tells us that, on the average, for every thousand-student-per-grade increment in SPANSIZE, mean school reading comprehension score increases by 20.969 points. Simultaneously, for every one percentage point increase in FREEPCT, mean reading comprehension score decreases by 0.309 points. Finally, for every one unit increment in INTERACT, mean school reading comprehension score decreases by 0.560 points.

Illustrating the Partial Derivative

Furthermore, taking the partial derivative tells us that the rate of change in Y with respect to X, holding Z constant is equal to:

$$\text{Partial Derivative} = 20.969 - 0.560Z$$

Using this result, if we set Z, our FREEPCT variable at values ranging from 0 to 100 using increments of 20, and including the FREEPCT median value of 44.5 in the middle of the distribution, we get the following:

| EFFECT SIZE | FREEPCT |
|---|---|
| 20.97 | 0.0 |
| 9.77 | 20.0 |
| -1.43 | 40.0 |
| -3.95 | 44.9 |
| -12.63 | 60.0 |
| -23.83 | 80.0 |
| -35.03 | 100.0 |

This tells us that among schools in Georgia, the initial benefits associated with school size for eighth grade reading compehension are diminished and quickly become increasing costs as the percentage of students eligible for free and reduced cost lunches increases.

At first, as we can see, for every one unit increment in SPANSIZE, mean reading comprehension score increases by 20.97 points. However, by the time FREEPCT has reached its median, the initial benefit has become a cost, a loss of 3.95 points for every one unit increment in SPANSIZE. When all students are eligible for free or reduced cost lunch, this cost has increased to 35.03 points per unit increment in size.

## TEXAS APPLICATIONS

This kind of analysis, estimating regression equations as in the Georgia example, and then taking partial derivatives, is precisely what we will do with the Texas data. Again, we are trying to determine if statistically significant and negative interaction terms appear, as they did in the research we are replicating.

If such interactions are present, we have found another state in which interaction between size and percent less-advantaged diminishes mean achievement measured at the school level. As the Georgia example makes clear, use of partial derivatives enables us to translate main effects and interaction effects into test score gains and losses.

However, if interactions are not present, our Texas results will not be consistent with findings from California, West Virginia, and, most recently, Georgia. The plausibility of claims to generalizability will be diminished.

## RESULTS

Tables 1 through 10 consititute our Texas replication. In nine of the ten analyses, we find statistically significant and negative interaction effects: as school size increases, the achievement costs for schools with less-advantaged students increase. The one exception is found for math in the fifth grade. (See Table 4.)

Examination of partial derivative values computed for varying values of FREEPCT is instructive. In table after table, we see gradual diminution of the initial gains associated with larger SPANSIZE levels, until the gains become increasingly burdensome costs .

### One Exception in Ten Analyses

In the one exceptional case, 5th grade math, the regression coefficient corresponding to SPANSIZE was also statistically non-significant. Only FREEPCT yielded a statistically significant finding. As a result, partial derivatives were not taken and effect sizes not reported in Table 4.

## TABLE 1
## Regression Results and Effect Size: Schools
## Reading: Mean Raw Scores
## Grade 3
## Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 6.126** (.100) |
| FREEPCT | -0.047*** (-.473) |
| INTERACT | -0.085** (-.124) |
| Constant Term | 31.820*** |
| Adjusted R-Squared | 31.5% |
| | N=3075 |

Partial Derivative = 6.126 - 0.085Z

| Effect Size | FREEPCT |
|---|---|
| 6.13 | 0.0 |
| 4.43 | 20.0 |
| 2.73 | 40.0 |
| 1.19 | 58.1! |
| 1.03 | 60.0 |
| -0.07 | 80.00 |
| -2.37 | 100.00 |

*** <.001
** <.01
* <.05
! Median

## TABLE 2
## Regression Results and Effect Size: Schools
## Math: Mean Raw Scores
## Grade 3
## Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| ENROLLMENT (Thousands) | 7.481*** (.127) |
| FREE/REDUCED (Percent) | -0.042*** (-.389) |
| INTERACTION | -0.095** (-.124) |
| Constant Term | 38.280*** |
| Adjusted R-Squared | 23.0% |
| | N=3076 |

Partial Derivative = 7.841 - 0.095Z

| Effect Size | FREEPCT |
|---|---|
| 7.84 | 0.0 |
| 5.94 | 20.0 |
| 4.04 | 40.0 |
| 2.32 | 58.1! |
| 1.14 | 60.0 |
| 0.24 | 80.00 |
| -1.66 | 100.00 |

*** <.001
** <.01
* <.05
! Median

TABLE 3
Regression Results and Effect Size: Schools
Reading: Mean Raw Scores
Grade 5
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 2.412<br>(.043) |
| FREEPCT | -0.054***<br>(-.553) |
| INTERACT | -0.055*<br>(-.081) |
| Constant Term | 35.476*** |
| Adjusted R-Squared | 37.2% |
| | N=2843 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

SPANSIZE not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 4
Regression Results and Effect Size: Schools
Math: Mean Raw Scores
Grade 5
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | -0.897<br>(-.011) |
| FREEPCT | -0.064***<br>(-.474) |
| INTERACT | -0.022<br>(-.022) |
| Constant Term | 45.535*** |
| Adjusted R-Squared | 23.9% |
| | N=2843 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

SPANSIZE and INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 5
Regression Results and Effect Size: Schools
Reading: Mean Raw Scores
Grade 8
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 7.886*** (.285) |
| FREEPCT | -0.049*** (-.300) |
| INTERACT | -0.115*** (-.255) |
| Constant Term | 38.498*** |
| Adjusted R-Squared | 21.9% |
| | N=1448 |

Partial Derivative = 7.886 - 0.115Z

| Effect Size | FREEPCT |
|---|---|
| 7.89 | 0.0 |
| 5.59 | 20.0 |
| 3.29 | 40.0 |
| 2.72 | 44.9! |
| 0.99 | 60.0 |
| -1.31 | 80.00 |
| -3.61 | 100.00 |

*** <.001
** <.01
* <.05
! Median

## TABLE 6
## Regression Results and Effect Size: Schools
## Math: Mean Raw Scores
## Grade 8
## Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 7.129** (.191) |
| FREEPCT | -0.068*** (-.310) |
| INTERACT | -0.137** (-.226) |
| Constant Term | 48.391*** |
| Adjusted R-Squared | 20.1% |
| | N=1444 |

Partial Derivative = 7.129 - 0.137Z

| Effect Size | FREEPCT |
|---|---|
| 7.13 | 0.0 |
| 4.39 | 20.0 |
| 1.65 | 40.0 |
| 0.98 | 44.9 |
| -1.09 | 60.0 |
| -3.83 | 80.00 |
| -6.57 | 100.00 |

*** <.001
** <.01
* <.05
! Median

TABLE 7
Regression Results and Effect Size: Schools
Writing: Mean Raw Scores
Grade 8
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 3.417***<br>(.171) |
| FREEPCT | -0.041***<br>(-.354) |
| INTERACT | -0.066***<br>(-.202) |
| Constant Term | 32.446*** |
| Adjusted R-Squared | 22.7% |
| | N=1441 |

Partial Derivative = 3.417 - 0.066Z

| Effect Size | FREEPCT |
|---|---|
| 3.42 | 0.0 |
| 2.10 | 20.0 |
| 0.78 | 40.0 |
| 0.45 | 44.9! |
| -0.54 | 60.0 |
| -1.86 | 80.00 |
| -3.18 | 100.00 |

*** <.001
** <.01
* <.05
! Median

## TABLE 8
## Regression Results and Effect Size: Schools
## Reading: Mean Raw Scores
## Grade 10
## Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 1.807*** (.169) |
| FREEPCT | -0.042*** (-.308) |
| INTERACT | -0.051*** (-.203) |
| Constant Term | 40.183*** |
| Adjusted R-Squared | 17.8% |
| | N=1197 |

Partial Derivative = 1.807 - 0.051Z

| Effect Size | FREEPCT |
|---|---|
| 1.81 | 0.0 |
| 0.79 | 20.0 |
| 0.14 | 32.7! |
| -0.23 | 40.0 |
| -1.25 | 60.0 |
| -2.27 | 80.00 |
| -3.29 | 100.00 |

*** <.001
** <.01
* <.05
! Median

TABLE 9
Regression Results and Effect Size: Schools
Math: Mean Raw Scores
Grade 10
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 3.187*** (.168) |
| FREEPCT | -0.049*** (-.204) |
| INTERACT | -0.092*** (-.208) |
| Constant Term | 46.231*** |
| Adjusted R-Squared | 10.5% |
| | N=1197 |

Partial Derivative = 3.187 - 0.092Z

| Effect Size | FREEPCT |
|---|---|
| 3.19 | 0.0 |
| 1.35 | 20.0 |
| 0.18 | 32.7! |
| -0.49 | 40.0 |
| -1.65 | 60.0 |
| -4.17 | 80.00 |
| -6.01 | 100.00 |

*** <.001
** <.01
* <.05
! Median

## TABLE 10
## Regression Results and Effect Size: Schools
## Writing: Mean Raw Scores
## Grade 10
## Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 0.927* (.113) |
| FREEPCT | -0.028*** (-.270) |
| INTERACT | -0.043*** (-.226) |
| Constant Term | 33.715*** |
| Adjusted R-Squared | 15.4% |
| | N=1190 |

Partial Derivative = 0.921 - 0.043Z

| Effect Size | FREEPCT |
|---|---|
| 0.92 | 0.0 |
| 0.06 | 20.0 |
| -0.49 | 32.7! |
| -0.80 | 40.0 |
| -1.66 | 60.0 |
| -2.52 | 80.00 |
| -3.38 | 100.00 |

*** <.001
** <.01
* <.05
! Median

In addition, partial derivatives and effect sizes are not reported for Table 3, reading in the 3rd grade. In this instance, while INTERACT was statistically significant and negative, SPANSIZE was not statistically significant.

Statistical Significance and Practical Importance: A Caveat

Evaluating INTERACT in terms of whether or not it is statistically significant may, in some instances, be misleading. After all, the Texas data set contains an enormous number of schools, and, as is well known, as sample size increases the probability of a statistically significant result increases, as well. In some instances, as a consequence, we are obliged to ask whether or not statistical significance corresponds to practical importance.

In the Texas analyses, this question seems pertinent only for grades 3 and 5, for which sample sizes are, by most standards, quite large, and relationships are not as strong as they are for grades 8 and 10.

As already noted, three of the four coefficients corresponding to INTERACT are statistically significant, with the 5th grade math achievement results yielding the one exception. The standardized regression coefficients corresponding to INTERACT for 3rd grade reading and math both have absolute values of .124. This is not large, but, by any standard known to us, not so small as to merit dismissal as indicating an absence of practical importance (see Pedhazur, 1997: 319-322).

The standardized regression coefficient for 5th grade reading, however, while statistically significant, has an absolute value of only .081. With 2843 schools reporting 5th grade reading scores, this may very well be one of those intances when statistical significance and practical importance are easily confused. Perhaps we we should acknowledge that we may have two exceptions rather than one.

## ALL TOLLED

It would have been entirely possible, even convenient, to use composite outcome measures to condense these findings, reducing the number of separate analyses from ten to four, one for each grade level. A good case can be made, however, that by including all ten analyses, in one table after another, we make unmistakably clear that the Texas data enable us to produce a replication which is consistent with earlier findings regarding size-by-SES interaction effects.

In Texas schools, too, as school size increases, the achievement costs associated with less-advantaged students increases. This is strikingly evident upon examination of the partial derivatives for varying values of FREEPCT.

The effects, moreover, are especially strong for the 8th and 10th grades. This was also true of our Georgia analyses.

## WHAT ABOUT SCHOOL DISTRICTS?

Some of the same literature which alerted us to the existence of size-by-SES interactions at the school level also raised the possibility of similar size-related achievement costs at the district level. At first blush, interest in district size, once school size has been taken into consideration, may seem to lack a strong rationale.

Recall, however, that before institutionalization of Tyack's (1974) "one best system," school districts were typically small, culturally distinctive, and socially rooted in local communities. Districts were democratically controlled in a near-plebiscitary manner (Katz, 1968).

Following widespread turn-of-the-century Progressive Era reforms, however, school districts became dramatically larger, and intensively centralized (Greer, 1972; Katz, 1975; Bowles and Gintis, 1976; Spring, 1994). Political control was taken over by moneyed social elites. Administrative control was increasingly professionalized. The everyday world of schooling became the object of micro-management by socially and geographically remote career policymakers and technicians (Callahan, 1964; Chubb and Moe, 1991). That such developments are likely to have adverse consequences seems now to be taken for granted (Bryk, 1998).

As a result, we have summarized the Texas district-level results in Tables 11 through 16.

Analyses for grades 3 and 5 were done at the district level, but, for each outcome measure in each grade, only FREEPCT had a statistically significant regression coefficient.

For grades grades 8 and 10, however, the regression results were more interesting. As before, the outcome measures for these grades are the reading, math, and writing subtests from the TAAS battery.

TABLE 11
Regression Results and Effect Size: Districts
Reading: Centered Scores
Grade 8
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE (Logged) | -0.200*** (-.107) |
| FREEPCT | -0.078*** (-.559) |
| INTERACT | -0.003 (-.031) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 32.0% |
| | N=943 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

## TABLE 12
## Regression Results and Effect Size: Districts
## Math: Centered Scores
## Grade 8
## Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE (Logged) | -0.433*** (-.166) |
| FREEPCT | -0.091*** (-.467) |
| INTERACT | 0.001 (.010) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 22.9% |
| | N=942 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 13
Regression Results and Effect Size: Districts
Writing: Centered Scores
Grade 8
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE (Logged) | -0.164*** (-.116) |
| FREEPCT | -0.052*** (-.497) |
| INTERACT | -0.005 (-.004) |
| Constant Term | All Variables Centered> |
| Adjusted R-Squared | 25.4% |
| | N=941 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 14
Regression Results and Effect Size: Districts
Reading: Centered Scores
Grade 10
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE (Logged) | -0.134** (-.078) |
| FREEPCT | -0.063*** (-.490) |
| INTERACT | -0.002 (-.022) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 24.3% |
| | N=909 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 15
Regression Results and Effect Size: Districts
Math: Centered Scores
Grade 10
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE (Logged) | -0.392*** (-.139) |
| FREEPCT | -0.084*** (-.400) |
| INTERACT | 0.001 (.003) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 16.7% |
| | N=909 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 16
Regression Results and Effect Size: Districts
Writing: Centered Scores
Grade 10
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE (Logged) | -0.224*** (-.166) |
| FREEPCT | -0.046*** (-.460) |
| INTERACT | -0.002 (-.029) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 23.3% |
| | N=906 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

## District Results

As with grades 3 and 5, the regression coefficients corresponding to INTERACT are not statistically significant in any of the 8th and 10th district-level analyses. The size-by-SES interaction effects, which were conspicuous at the school level, are not present at the district level. As a result, we cannot say that as district size increases, the achievement costs associated with less-advantaged students become more burdensome.

However, in each of the analyses for grades 8 and 10, there is a statistically significant and negative main effect corresponding to SPANSIZE. In other words, for each outcome measure in each grade, as school size increases, achievement levels for all students decrease. The effects are not strong, it is true, but their test-to-test consistency for the 8th and 10th grades is a compelling argument for their importance.

In preliminary analyses (not reported here), these costly main effects were masked for two reasons. First, at the district level, multicollinearity is more troublesome than at the school level. Second, SPANSIZE is more sharply skewed to the right at the district level than at the school level.

To compensate for multicollinearity, we used centered score regression, meaning that all variables were expressed as deviations about their means (Kromrey and Foster-Johnson, 1998; also see the discussion under K-12 SINGLE-UNIT SCHOOLS, reported below ). To compensate for skewness, SPANSIZE was transformed into its natural logarithm before centering (Mirer, 1995: 37-40). Following these commonplace adjustments, negative main effects for SPANSIZE became quite evident.

## Absence of Comparability with Georgia District Results

The results for Texas school districts are different from those we found in Georgia. Georgia school-level effects were conspicuously consistent, and the effect sizes even larger than in Texas. However, at the district level, the statistically significant and negative SPANSIZE main effects were present only in eighth grade analyses, and not for all outcome measures.

In part, this difference between the two states is due to the much smaller number of districts in Georgia, diminishing statistical power and making statistical significance more difficult to reach. More important, however, is the simple absence of SPANSIZE main effects in most of the Georgia analyses.

K-12 SINGLE-UNIT SCHOOLS: AN ADDENDUM

Contemporary testimonials to the traditional effectiveness and McGuffey's-Reader charm of the rural one-room school are, no doubt, cyclonically overblown and hoplessly romanticized (Kaestle, 1983). Nevertheless, in our foregoing rationale for district-level analyses, we saw that a favorable assessment of the common school era is not without merit.

For many, the 19th century common school, where all studied the same things in the same way in the same place, remains a cherished model for American public education (Perkinson, 1991). Affection for this rural community resource remains strong, even after it has ceased to concretely exist as anything but a museum piece (Spring, 1994).

Little noticed in the literature on educational research, however, is the fact that an approximate synthesis of the 19th common school ideal and 20th century educational differentiation has been attempted. It takes the form of the typically rural single-unit school, with grades K through 12 under one administration and one roof (Carlson, 1994; Howley and Harmon, 1996 and 1997).

In Georiga, we noted, there were 10 such schools out of a total of 1626. In Texas there are 132 single-unit schools, still only 2 percent of the 6288 schools in our data set. Nevertheless, 132 schools is certainly enough to provide opportunities of interesting statistical analyses.

## Occasional Claims for the Single-Unit School

Performance claims for single-unit schools are not abundant. Sustained evaluations, to the best of our knowledge, do not exist.

In a study of single-unit schools in Louisiana, however, Franklin and Glascock (1996) tentatively concluded that 6th and 7th graders had higher achievement levels in single-unit schools than in either elementary schools or middle schools. Futhermore, students in grades 9 through 12 were less likely to drop out or to have disciplinary problems if attending a single-unit school.

Beyond this, little or nothing has been reported regarding the performance of single-unit schools.

## Size-by-SES Interactions with Single-Unit Schools

Whatever the unidentified virtues and limitations of single-unit schools, the most important question for us is perfectly obvious: are the costs associated with less-adavantaged students exacerbated as school size increases? Are single unit schools more, or, perhaps, less, equitable institutions than the typically larger other kinds of schools in Texas?

As before, we will answer these questions through analyses aimed at detecting and measuring size-by-SES interaction effects.

## Achievement in Single-Unit Schools

The means and standard deviations reported in Table 17 make clear that there is very little difference between single-unit schools and other schools in terms of measured achievement. Achievement test results for 5th, 8th, and 10th grades show a consistent advantage for single-unit schools, but the differences are small. The same is true for the single-unit school disadvantages in reading and math in the third grade.

TABLE 17
Means and (Standard Deviations)

| | Single Unit | All Others |
|---|---|---|
| FREEPCT | 49.8% (18.8) | 50.2% (27.5) |
| SPANSIZE (In Tens) | 2.3 (1.4) | 15.8 (15.9) |
| INTERACT | 1.1 (0.9) | 6.9 (7.6) |
| Enrollment | 269.4 (170.2) | 621.2 (460.2) |
| Reading 3 | 28.9 (3.5) | 29.3 (2.8) |
| Math 3 | 35.7 (3.9) | 36.2 (3.0) |
| Reading 5 | 32.6 (3.1) | 32.4 (2.8) |
| Math 5 | 42.1 (4.0) | 41.7 (3.9) |
| Reading 8 | 37.5 (3.3) | 36.6 (3.9) |
| Math 8 | 46.7 (4.3) | 45.3 (5.2) |
| Writing 8 | 31.4 (2.9) | 30.5 (2.7) |
| Reading 10 | 39.2 (3.0) | 38.6 (3.0) |
| Math 10 | 45.9 (5.0) | 44.3 (5.3) |
| Writing 10 | 33.2 (2.2) | 32.5 (2.3) |

## FREEPCT in Single-Unit Schools

As with achievement levels, when single-unit schools are compared to other schools with regard to mean percent receiving free or reduced cost lunch (FREEPCT), the difference is inconsequential.

## SPANSIZE in Single-Unit Schools

Single-unit schools are far from homogeneous with respect to size, with enrollments ranging from 61 to 997. Nevertheless, on the average, they are substantially smaller than the other schools. The other Texas schools have, on the average, 2.3 times more students than single-unit schools. Moreover, when enrollment per grade level (SPANSIZE) is used as our school size measure, the other schools average 6.9 times larger than single-unit schools.

## Unstandardized Coefficients and Variability in SPANSIZE

For present purposes, however, differences between single-unit and other schools with regard to mean SPANSIZE are less consequential than differences with regard to variability in SPANSIZE. For the the other schools, the standard deviation for SPANSIZE is 11.4 times larger than the same measure for single-unit schools.

This is important because the magnitude of unstandardized regression coefficients is a function of the ratio of the variability of the dependent variable to the independent variable. Table 17 makes clear that the variability of our achievement test outcome measures differs very little when comparing single-unit and other schools.

This confluence of statistical circumstances, a large difference in variability in SPANSIZE but little difference in the variability of outcome measures, means that regression analyses for single-unit schools are likely to yield unusually large unstandardized coefficients corresponding to SPANSIZE. Moreover, in view of the multiplicative nature of INTERACT, the same will be true of this variable.

Since standardized coefficients, tests of significance, and other measures remain unaffected, however, awareness of this statistical phenomenon is sufficient to guard against misinterpretation.

Regression Analyses and Sample Size

As already noted, statistically significant findings are sometimes, for all practical purposes, artifacts of large sample size. The same is true of non-significant findings with small samples. As a result, regression analyses of the performance of 132 single-unit schools force us to address a question very different from any raised by our previous analyses with much larger numbers of other schools. Specifically, is absence of statistical significance for INTERACT or any other independent variable an artifact of limited statistical power due to small sample size?

Multicollinearity

Questions raised by use of a comparatively small number of cases become even more troublesome when multiplicative interaction terms are used. Given their nature, such variables make it likely that they will be closely correlated the other independent variables, from which they were created (Aiken and West, 1991).

As correlations among independent variables increase, estimates of regression coefficients become less precise. This is due to inflation of standard errors of estimates of the coefficients. In the most extreme case, when an independent variable is a perfect linear function of one or more others, the standard errors of the estimates becomes infinitely large, and coefficients cannot be estimated.

Correlations among independent variables are rarely perfect, however, raising the question "How large is too large?" A variety of statistical tools has been developed to assist in answering this question, though each has an unsettling rule-of-thumb character. Among the most commonly used is the variance inflation factor (VIF).

The oft-cited rule-of-thumb of the VIF is a numerical magnitude of 10 (Chatterjee and Price, 1991; Kennedy, 1992; Gujurati, 1995). In other words, if no independent variable in a multiple regression equation corresponds to a VIF of 10 or larger, multicollinearity will not result in imprecise estimates.

The VIF's in our school-level analyses using the entire data set were all less than 10. The same is true of analyses with our single-unit school data set.

Nevertheless, since some of the VIF's are as large as 9.9, since the single-unit data set has fewer cases than our other analyses, and since a VIF of 10, in spite of its routine endorsement, may be too large (Fox, 1997: 338-340), we have sought to enhance statistical power by using centered score regression (Kromrey and Foster-Johnson, 1998). This, of course, is the same procedure we used to address multicollinearity in our district-level analyses reported above.

Instead of employing raw values of the original independent variables, deviations around means are computed. These centered variables are then used in constructing the interaction term and in doing the regression analysis. Resulting VIF's, even with multiplicative interaction terms, will be approximately 1.0, eliminating inflation of the standard errors of the estimates, enhancing statistical power, and making it less likely that we will fail to detect consequential relationships.

Single-Unit School Results

Tables 18 through 27 replicate Tables 1 through 10, though now our analyses are now limited to single-unit schools. Statistically significant size-by-SES interaction effects are found only in the analyses using 5th grade reading scores and 5th grade math scores as outcome measures. (See Tables 20 and 21).

Even in these two instances, moreover, partial derivative values were not calculated: though INTERACT was statistically significant in each instance, SPANSIZE was not.

Tables 18 through 27 are striking precisely because there is so little in them. Not only are most coefficients

TABLE 18
Regression Results and Effect Size: Single-Unit Schools
Reading: Centered Scores
Grade 3
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 30.865<br>(.115) |
| FREEPCT | -0.039*<br>(-.199) |
| INTERACT | -0.999<br>(-.077) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 2.7% |
| | N=129 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

SPANSIZE and INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 19
Regression Results and Effect Size: Single-Unit Schools
Math: Centered Scores
Grade 3
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 32.017<br>(.117) |
| FREEPCT | -0.018<br>(-.087) |
| INTERACT | -0.720<br>(-.050) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 0.0% |
| | N=129 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

SPANSIZE, FREEPCT, INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

## TABLE 20
## Regression Results and Effect Size: Single-Unit Schools
## Reading: Centered Scores
## Grade 5
## Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 11.509<br>(.053) |
| FREEPCT | -0.030*<br>(-.173) |
| INTERACT | -2.462*<br>(-.215) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 4.5% |
| | N=127 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

SPANSIZE not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 21
Regression Results and Effect Size: Single-Unit Schools
Math: Centered Scores
Grade 5
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 39.001<br>(.114) |
| FREEPCT | -0.047*<br>(-.173) |
| INTERACT | -3.112*<br>(-.173) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 2.4% |
| | N=125 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

SPANSIZE not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 22
Regression Results and Effect Size: Single-Unit Schools
Reading: Centered Scores
Grade 8
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | -2.158<br>(-.015) |
| FREEPCT | -0.067***<br>(-.366) |
| INTERACT | 0.566<br>(.046) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 11.6 % |
| | N=126 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

SPANSIZE and INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 23
Regression Results and Effect Size: Single-Unit Schools
Math: Centered Scores
Grade 8
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 0.814<br>(.003) |
| FREEPCT | -0.099***<br>(-.406) |
| INTERACT | 1.844<br>(.113) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 15.9% |
| | N=126 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

SPANSIZE and INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 24
Regression Results and Effect Size: Single-Unit Schools
Writing: Centered Scores
Grade 8
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | -8.051<br>(-.040) |
| FREEPCT | -0.064***<br>(-.391) |
| INTERACT | 0.218<br>(.020) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 13.6 % |
| | N=125 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

SPANSIZE and INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 25
Regression Results and Effect Size: Single-Unit Schools
Reading: Centered Scores
Grade 10
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 18.790 (.088) |
| FREEPCT | -0.052*** (-.315) |
| INTERACT | -0.841 (-.076) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 8.1% |
| | N=131 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

SPANSIZE and INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

TABLE 26
Regression Results and Effect Size: Single-Unit Schools
Math: Centered Scores
Grade 10
Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 24.284 (.068) |
| FREEPCT | -0.066** (-.241) |
| INTERACT | -0.975 (-.053) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 3.7% |
| | N=131 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

SPANSIZE and INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

## TABLE 27
## Regression Results and Effect Size: Single-Unit Schools
## Writing: Centered Scores
## Grade 10
## Unstandardized and (Standardized) Coefficients

| | |
|---|---|
| SPANSIZE | 18.601<br>(.112) |
| FREEPCT | -0.041***<br>(-.343) |
| INTERACT | -0.863<br>(-.109) |
| Constant Term | All Variables Centered. |
| Adjusted R-Squared | 10.6% |
| | N=131 |

Partial Derivative = Not Calculated.

| Effect Size | FREEPCT |
|---|---|

SPANSIZE and INTERACT not statistically significant.

*** <.001
** <.01
* <.05
! Median

corresponding to INTERACT and SPANSIZE statistically non-significant, but numerical magnitudes of the coefficients are quite small. This, very clearly, is not a set of circumstances in which too-small sample size has diminished statistical power so that even strong and consequential relationships are statistically trivialized. There simply are no strong relationships.

Small Is Better?

How best to interpret the unit-school size results? They, too, seem to fit neatly into the growing body of empirical research which holds that school size is negatively associated with most measures of educational productivity and equity (see, for example, Walberg and Walberg, 1995; Stevens and Peltier, 1995; Fowler, 1995; Mik and Flynn, 1996; Riordan, 1997).

Our results, moreover, seem emphatically not to be statistical artifacts. Indeed, Table 17 makes clear that there is as much variability in FREEPCT and in each of our eight outcome measures in the single-unit school data set as in the total data set. SPANSIZE and, therefore, INTERACT do not vary nearly so much, but they are far from static. In fact, the coefficients of variation for SPANSIZE and INTERACT for single-unit schools are 1.6 and 1.2., while the same measures for all other schools are only 0.9 and 1.0.

In addition, the realtionship between FREEPCT, a variable that always "works," and both outcome measures used in the 3rd and 5th grades is suprisingly weak, and, in one instance, 3rd grade math, statistically non-significant. This, also, suggests that the achievement score costs associated with less-advantaged students are, indeed, diminished in single-unit schools.

In short, the absence of statistical significance for INTERACT and for SPANSIZE, along with diminished FREEPCT coefficients and very small R-squared values, all suggest that single-unit schools are more equitable institutions than the typically larger other schools.

## CONCLUSION

School size is a variable which continues to receive attention as a determinant of educational achievement. Recently, size has figured conspicuously in discussions of educational _equity_, as well as effectiveness.

Among the most compelling reasons for ongoing and refocused interest in school size are reports of school-level size-by-SES interaction effects, which raise both effectiveness and equity issues. Having replicated the research which generated interest in these effects using first a Georgia data set, and now a large Texas data set, we have found the effects to be robust, indeed.

It is true that the Texas school-level effects are not as large as those we found in Georgia. Nevertheless, the Texas outcomes exhibit striking grade-to-grade, test-to-test consistency. The generalizability of the claim that the achievement costs for less-advantaged students are exacerbated by increasing school size has, indeed, gained additional credibility. With the unit-school analyses, the claim that small is good becomes still more compelling.

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# APPENDIX

Bivariate correlations, computed above and below the median for school size, of FREEPCT with achievement measures for grades 3, 5, 8, and 10. Notice that in every instance, the correlation for larger schools, those above the median, has a larger absolute value.

## Grade 3

| | Reading | Mathematics |
|---|---|---|
| Above | -.631 | -.552 |
| Below | -.483 | -.394 |

N=3076

## Grade 5

| | Reading | Mathematics |
|---|---|---|
| Above | -.686 | -.551 |
| Below | -.553 | -.452 |

N=3076

## Grade 8

| | Reading | Mathematics | Writing |
|---|---|---|---|
| Above | -.789 | -.731 | -.701 |
| Below | -.239 | -.244 | -.289 |

N=1449

## Grade 10

| | Reading | Mathematics | Writing |
|---|---|---|---|
| Above | -.675 | -.560 | -.587 |
| Below | -.217 | -.157 | -.205 |

N=1199

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EFF-088 (Rev. 9/97)